

THE VISCERAL AFFERENT PATHWAY IN THE ELASMOBRANCH, *SCYLLIUM CANICULA*

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With the elaborate morphological development of the autonomic nervous system in the higher vertebrates, the efferent innervation of the abdominal viscera has tended toward physiological differentiation. However, while the orthodox view holds that the cranial parasympathetic carries the excitatory fibers for the stomach and intestines, and the sympathetic contains the inhibitory fibers, Langley (1898) found inhibitory fibers to the stomach in the vagus of the rabbit, Morat (1893) found excitatory fibers to the stomach and intestine in the splanchnic of the dog, and Carlson, Boyd and Pearcy (1922) have found that both splanchnics and vagi of the cat carry both kinds of fibers to the stomach. Even in the elasmobranch fishes, where the autonomic nervous system is still morphologically simple, the two motor functions are not distinctly separated. Bottazzi (1901) and Müller and Liljestrand (1918) have reported motor activity of the stomach on stimulation of either the vagus or the first sympathetic ganglion, and the latter workers report also inhibitory bundles in the vagus.

On the afferent side of visceral innervation there is ample evidence in the higher vertebrates that there are fibers running from the abdominal viscera to the cord by way of the autonomic system (Head, 1893; Ranson and Billingsley, 1918). Stimulation of the stomach causes acceleration of the heart, according to Dmitrenko (Ranson, 1921), through afferent fibers mainly in the splanchnic nerve, but to some extent in the vagus. Brodie and Russell (1900) obtained slowing of the heart on stimulation of the central ends of the vagi to the stomach and concluded that afferent impulses are carried up the vagi as well as along the splanchnics in the cat.

In the elasmobranch fishes one might expect the vagi to take the larger part in carrying afferent fibers from the abdominal viscera although the writer found in the literature no reference to the vagus as an afferent pathway from these organs. Lyon (1926) noted cardio-inhibition on stimulating the stomach and other abdominal organs in

sand sharks (*Carcharias*), but reported no attempt to locate the afferent pathway. In a teleostean fish (eel) McWilliam (1885) could obtain no cardio-inhibition on stimulation of the abdominal organs, and while stimulation of the central end of the vagus on the oesophagus caused a marked cardio-inhibitory response, stimulation of either vagus after it had passed to the stomach had no effect. Mills (1886), however, working on the teleost, *Batrachus tau*, never failed to get reflex cardio-inhibition from the stomach and intestine, but he made no examination of the nervous pathways involved.

MATERIALS AND METHOD

The method of operating on *Scyllium canicula* out of water, and of recording the heart and respiratory rates has been described in a previous paper (Lutz, 1930). The spinal cord was transected at a desired level and pithed posteriorly. The gills were perfused through the mouth and respiration quickly became regular. The vagus and its branches were exposed through the anterior cardinal sinuses. The first large sympathetic ganglion and accessory ganglia were exposed through the posterior cardinal sinuses. Both operations were, of course, accompanied by unavoidable profuse bleeding, but since the writer found that the medullary centers of *Scyllium* would continue to be reflexly functional for about one hour after aortic transection, the bleeding did not interfere.

RESULTS

Mechanical and faradic stimulation of the stomach, spiral valve, or mesentery caused cardiac and respiratory inhibition when the spinal cord was destroyed posteriorly from the first vertebra, but not when the vagi were cut either immediately posterior to the origin of the fourth branchial division (fifth branchial nerve) or just posterior to the origin of the cardiac rami from the visceral branches (Figs. 1 and 2, *A*, *B* and *C*). With the medulla, cord to the fourteenth vertebra, and cardiac vagi intact neither cardiac nor respiratory inhibition could be elicited on faradic stimulation of the first large sympathetic ganglion, but the same stimulus applied to the parietal peritoneum 3 mm. from the ganglion or to the adjacent oesophageal wall produced marked cardiac diastolic inhibition and sometimes respiratory inhibition as well (Fig. 2, *E* and *F*). Removal of the large sympathetic ganglion on each side and several accessory ganglia posterior to it or destruction of the spinal cord as high as the first vertebra failed to prevent elicitation of the inhibitory responses on stimulation of the stomach, spiral valve, or mesentery so long as the visceral

branches of the vagi remained intact. Faradic stimulation of the central end of either visceral branch of the vagus, cut at the stomach, also produced cardio-inhibition. Vigorous mechanical or faradic

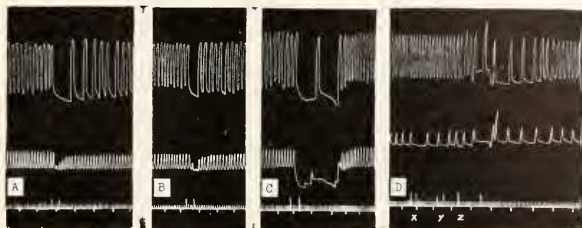


FIG. 1. Reflex cardiac and respiratory responses on stimulation of the abdominal viscera. Forebrain and cord from the third vertebra destroyed. Upper record, heart; middle, respiration. The large divisions on the time-signal record are ten seconds. *A*, spiral valve pinched with forceps. *B*, stomach pinched. *C*, gentle blowing on the viscera. *D*, the vagi have been cut below the cardiac rami. *x*, spiral valve pinched. *y*, stomach pinched. *z*, points of the forceps inserted in the nasal openings.

stimulation of the liver and the testis failed to evoke either cardio-inhibition or respiratory slowing even with the entire cord intact. Stimulation of the kidney, epididymis, ovary, and uterus were effec-

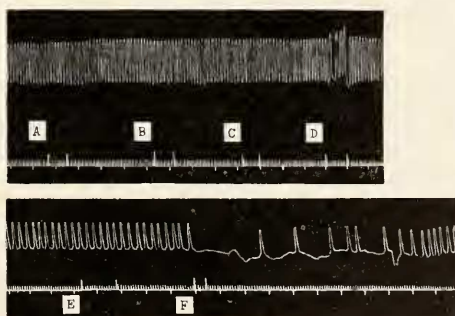


FIG. 2. Reflex cardiac inhibition. Forebrain and cord from the thirteenth vertebra destroyed. Vagi cut below the cardiac rami. *A*, stomach pinched with forceps. *B*, faradic stimulation of the stomach. *C*, spiral valve pinched. *D*, forceps inserted in the nasal openings. *E*, faradic stimulation of the first large sympathetic ganglion. *F*, faradic stimulation of the peritoneum 5 mm. from the ganglion.

tive in producing both reflexes when the cord was not destroyed (Fig. 3). Stimulation of the kidney was without effect with the cord pithed posterior to the third vertebra. No attempt was made to locate the portion of the cord receiving the afferent fibers, and no examination

of the relation of the vagus to the kidney, epididymis, ovary, and uterus was made.

The results presented above indicate that in the elasmobranch, *Scyllium canicula*, the vagus carries afferent fibers from the stomach, spiral valve, and mesentery. In view of the fact that sensory stimu-

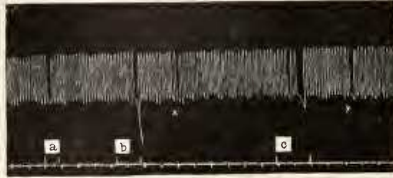


FIG. 3. Reflex cardiac inhibition. Entire cord intact. *a*, uterus pinched with forceps. *b* and *c*, ovary pinched. *x*, viscera handled. *y*, ovary handled.

lation at a great variety of points produces reflex cardiac and respiratory inhibition in *Scyllium* (Lutz, 1929), the failure of stimulation of the first large splanchnic ganglion to elicit these responses may be taken to indicate a lack of afferent fibers through this ganglion. The liver and testis also have no afferent fibers, stimulation of which gives either cardiac or respiratory response. Lyon (1926) likewise obtained no cardio-inhibition on stimulation of the liver in sand sharks (*Carcharias*).

SUMMARY

1. The vagus in the elasmobranch, *Scyllium canicula*, is an afferent pathway from the stomach, spiral valve, and mesentery.
2. There are no afferent fibers passing through the first large sympathetic ganglion or from the liver and testis, stimulation of which produces either cardiac or respiratory inhibition.
3. Removal of the sympathetic ganglia or destruction of the spinal cord as high as the first vertebra fails to prevent elicitation of the inhibitory reflexes provided the visceral branches of the vagi remain intact.
4. Faradic stimulation of the central end of a visceral branch of the vagus at the stomach produces cardiac and respiratory inhibition.

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